EENS 1110	Physical Geology
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Volcanoes and Volcanic Eruptions	

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Magmas and Lava

Since volcanic eruptions are caused by ***magma*** (a mixture of liquid rock, crystals, and dissolved gas) expelled onto the Earth's surface, we'll first review the characteristics of magma that we covered previously.

Three basic types of magma:

1. ***Mafic or Basaltic***-- SiO_2 45-55 wt%, high in Fe, Mg, Ca, low in K, Na
2. ***Intermediate or Andesitic***-- SiO_2 55-65 wt%, intermediate. in Fe, Mg, Ca, Na, K
3. ***Felsic or Rhyolitic***-- SiO_2 65-75%, low in Fe, Mg, Ca, high in K, Na.

Gases - At depth in the Earth nearly all magmas contain gas. Gas gives magmas their explosive character, because the gas expands as pressure is reduced.

- Mostly H_2O with some CO_2
- Minor amounts of Sulfur, Cl , and F
- Felsic magmas usually have higher gas contents than mafic magmas.

Temperature of Magmas

- Mafic/Basaltic - 1000-1200°C
- Intermediate/Andesitic - 800-1000°C
- Felsic/Rhyolitic - 650-800°C.

Viscosity of Magmas

Viscosity is the resistance to flow (opposite of fluidity). Depends on composition, temperature, & gas content.

- Higher SiO_2 content magmas have higher viscosity than lower SiO_2 content magmas
- Lower Temperature magmas have higher viscosity than higher temperature magmas.

Thus, basaltic magmas tend to be fairly fluid (low viscosity), but their viscosity is still 10,000 to 100,0000 times more viscous than water. Rhyolitic magmas tend to have even higher viscosity, ranging between 1 million and 100 million times more viscous than water. (Note that solids, even though they appear solid have a viscosity, but it very high, measured as trillions time the viscosity of water). Viscosity is an important property in determining the eruptive behavior of magmas.

Summary Table						
Magma Type	Solidified Volcanic Rock	Solidified Plutonic Rock	Chemical Composition	Temperature	Viscosity	Gas Content
Mafic or Basaltic	Basalt	Gabbro	45-55 SiO_2 %, high in Fe, Mg, Ca, low in K, Na	1000 - 1200 °C	Low	Low
Intermediate or Andesitic	Andesite	Diorite	55-65 SiO_2 %, intermediate in Fe, Mg, Ca, Na, K	800 - 1000 °C	Intermediate	Intermediate
Felsic or Rhyolitic	Rhyolite	Granite	65-75 SiO_2 %, low in Fe, Mg, Ca, high in K, Na	650 - 800 °C	High	High

The Products of Volcanic Eruptions

Lava Flows

When magma reaches the surface of the earth, it is called lava. Since it its a liquid, it flows downhill in response to gravity as a lava flows. Different magma types behave differently as lava flows, depending on their temperature, viscosity, and gas content.

- *Pahoehoe Flows* - Basaltic lava flows with low viscosity start to cool when exposed to the low temperature of the atmosphere. This causes a surface skin to form, although it is still very hot and behaves in a plastic fashion, capable of deformation. Such lava flows that initially have a smooth surface are called pahoehoe flows. Initially the surface skin is smooth, but often inflates with molten lava and expands to form *pahoehoe toes* or rolls to form ropey pahoehoe. (See figure 9.3d in your text). Pahoehoe flows tend to be thin and, because of their low viscosity travel long distances from the vent.

- *A'A' Flows* - Higher viscosity basaltic and andesitic lavas also initially develop a smooth surface skin, but this is quickly broken up by flow of the molten lava within and by gases that continue to escape from the lava. This creates a rough, clinkery surface that is characteristic of an A'A' flow (see figure 9.3e in your text).

- *Lava Tubes* - Once the surface skin becomes solid, the lava can continue to flow beneath the surface in lava tubes. The surface skin insulates the hot liquid lava form further cooling. When the eruption ends, liquid lava often drains leaving an open cave (see figure 9.3 in your text).

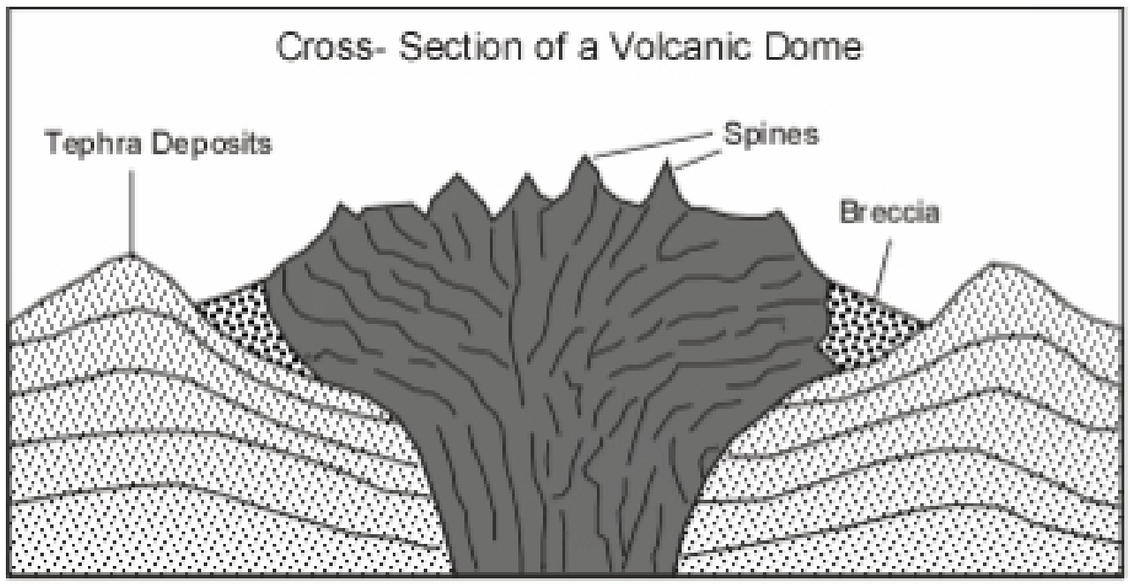
- *Pillow Lavas* - When lava erupts on the sea floor or other body of water, the surface skin forms rapidly, and, like with pahoehoe toes inflates with molten lava. Eventually these inflated balloons of magma drop off and stack up like a pile of pillows and are called pillow lavas. Ancient pillow lavas are readily recognizable because of their shape, their glassy margins and radial fractures that formed during cooling (see figure 9.4b in your text).

- *Columnar Jointing* - When thick basaltic or andesitic lavas cool, they contract. The contraction results in fractures and often times results in a type of jointing called columnar jointing. The columns are usually hexagonal in shape. This often happens when lavas pool in depressions or deep canyons (see figure 9.4a in your text).

- *Siliceous Lava Flows* - High viscosity andesitic and rhyolitic lava flows, because they can't flow very easily, form thick stubby flows that don't move far from the vent.

- *Lava Domes or Volcanic Domes* - result from the extrusion of highly viscous, gas poor andesitic and rhyolitic lava. Since the viscosity is so high, the lava does not flow away from the vent, but instead piles up over the vent. Blocks of nearly solid lava break off the outer surface of the dome and roll down its flanks to form a breccia around the margins of domes.

The surface of volcanic domes are generally very rough, with numerous spines that have been pushed up by the magma from below.



Pyroclastic Material

If the magma has high gas content and high viscosity, the gas will expand in an explosive fashion and break the liquid into clots that fly through the air and cool along their path through the atmosphere. Alternatively it blast out solid pieces of rock that once formed the volcanic edifice. All of these fragments are referred to as ***Pyroclasts*** = hot, broken fragments. Loose assemblages of pyroclasts called ***tephra***. Depending on size, tephra can be classified as bombs. blocks, lapilli, or ash.

Tephra and Pyroclastic Rocks		
Average Particle Size (mm)	Unconsolidated Material (Tephra)	Pyroclastic Rock
>64	Bombs or Blocks	Agglomerate
2 - 64	Lapilli	Lapilli Tuff
<2	Ash	Ash Tuff

- ***Blocks*** are angular fragments that were solid when ejected.

- ***Bombs*** have an aerodynamic shape indicating they were liquid when ejected.

- Bombs and lapilli that consist mostly of gas bubbles (***vesicles***) result in a low density highly vesicular rock fragment called ***pumice***.